Distributed Control Applications Within Sensor Networks

A Thesis submitted in partial fulfilment of the Requirements for the degree of

Bachelor of Technology

In

Electronics and Communication and

Master of Technology

In

Communication and signal processing

By

Sandeep Kumar Sahoo

710EC4056

Under The Guidance Of

Prof.Siddharth Deshmukh

Department of Electronics and Communication Engineering
National Institute of Technology, Rourkela
Rourkela, Odisha, India, 769008
May 2015

Dedicated to...

My Dear Friends

My parents and my sisters

DEPT. OF ELECTRONICS AND COMMUNICATION ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA
ROURKELA, ODISHA, INDIA – 769008

Certificate

This is to certify that the work in the thesis entitled **Distributed Control Applications Within Sensor Networks** by **Sandeep Kumar Sahoo** is a record of an original research work carried out by him during the 2014 - 2015 under my supervision and guidance in partial fulfilment of the requirements for the award of dual degree (Bachelor of Technology in Electronics and Communication and Master of Technology in Communication and Signal Processing), National Institute of Technology, Rourkela. Neither this thesis nor any part of it, to the best of my knowledge, has been submitted for any degree or diploma elsewhere.

Prof.Siddharth Deshmukh
Department of Electronics and Communication Engg.
NIT Rourkela

Date:

Place:

DEPT. OF ELECTRONICS AND COMMUNICATION ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA
ROURKELA, ODISHA, INDIA – 769008

Declaration

I certify that

a) The work contained in the thesis is original and has been done by myself under the general supervision of my supervisor.

b) The work has not been submitted to any other Institute for any degree or diploma.

c) I have followed the guidelines provided by the Institute in writing the thesis.

d) Whenever I have used materials (data, theoretical analysis, and text) from other sources, I have given due credit to them by citing them in the text of the thesis and giving their details in the references.

e) Whenever I have quoted written materials from other sources, I have put them under quotation marks and given due credit to the sources by citing them and giving the required details in the references.

Sandeep Kumar Sahoo

710EC4056

Date :

Acknowledgements

It is my immense pleasure to avail this opportunity to express my gratitude, regards and heartfelt respect to Prof. Siddhartha Deshmukh, Department of Electronics and Communication Engineering, NIT Rourkela for his endless and valuable guidance prior to, during and beyond the tenure of the project work. His priceless advices have always lighted up my path whenever I have struck a dead end in my work. It has been a rewarding experience working under his supervision as he has always delivered the correct proportion of appreciation and criticism to help me excel in my field of research.

I would like to express my gratitude and respect to Prof. S. K. Patra, Prof. K. K. Mahapatra, Prof. S. Meher, Prof. S.K.Behera and Prof. S.K. Das for their support, feedback and guidance throughout my course duration. I would also like to thank all the faculty and staff of the ECE department, NIT Rourkela for their support and help during the five years of my student life in the department.

Sandeep Kumar Sahoo

ABSTRACT

A mobile Ad-hoc network consists of wireless nodes communicating with each other without the need for an external support or supervision, where all the moving nodes potentially contribute to the routing of data packets. Due to the free moving ability of the nodes in a ad hoc network model, there is a need of routing protocols which can adapt dynamically to the changing topology. In this project a routing protocol which can perform best in ad hoc mode with limited resource conditions like bandwidth, storage capacity, battery power, CPU capacity and storage capacity. Routing protocols Dynamic Source Routing (DSR), Destination Sequenced Distance Vector (DSDV), Optimized link state Routing (OLSR) and ad hoc on-demand distance vector (AODV) routing are simulated for this kind of scenario. The performances of these routing protocols are evaluated through PDR (Packet Delivery Ratio), Routing overhead, End to End Delay and Throughput.

Contents

1

Introduction

Sensor networks (SNs) are picking up a part of significance among the research group.Embeded systems playing important part in our everyday lives. Controllers, sensors and actuators all are embedded systems performing specified functions through proper programming. Complexity of embedded computing increases as range of application increasing rapidly. An excellent example would be automobile industry. Comfortable driving experience provided through several embedded system working together. Late advancements in MEMS (microelectromechanical) innovation have given us an abundance of shoddy, adjustable, implanted sensor frameworks fit for remote correspondence among one another. The upside of remote SNs is huge conveying and keeping up a system of a great many hubs is unfeasible considering large number of miles of wire that would be required for the associations. A few equipment stages are accessible, grown by both new companies and universities.

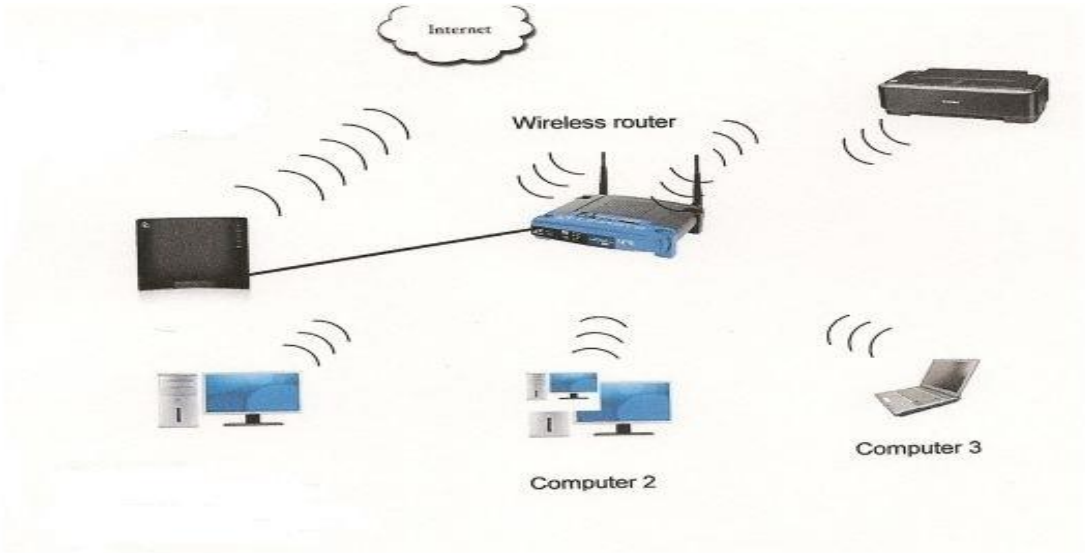
1.1 Motivation

This thesis carries out the modelling and design of SN(sensor network) as a Mobile Ad-hoc Network (MANET).It is a self-arranging system made out of portable hubs with no altered foundation. In a MANETs, there are no contrast between a host node and a switch so that all hubs can be source and forwarders of movement. Additionally, all MANET parts can be versatile. They are providing reliable communication in a variety of hostile environment for example, correspondence for the defence or in calamity recuperation circumstance when all the communication infrastructures are down. An imperative and vital issue for portable specially appointed systems is to discovering the root in the middle of destination and source that is a challenge because of the dynamism of topology. Routing protocols for Mobile Ad-hoc Network could be varying depending on the scenario of application and system structural planning. Specially appointed correspondence idea permits clients to correspond with one another in a transitory way with no unified administration and in a dynamic topology those progressions every now and again. Every node taking an interest in this system should act as both a host or a router and must in this way are willing to send data packet for other mobile nodes. This is the reason that traditional routing protocols used in wired network connections are not appropriate and there is a requirement for other routing protocol. Notwithstanding the

way that hubs in impromptu systems are frequently extremely constrained in resources (bandwidth, storage capacity, battery power, CPU capacity and storage capacity) a key test in the outline of such protocol is robustness, simplicity and energy conserving.

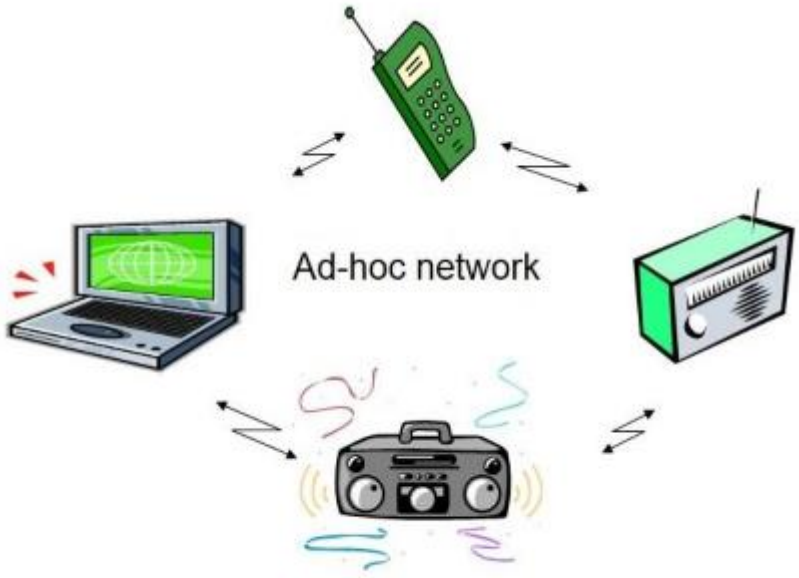
1.2 Wireless Network

The wireless network is the network which uses radio frequency for transmitting and receiving data on air. The most important benefit as compared to wired networks is to eliminate the problem of heavy cables and wireless network can be created easily and fast where we cannot wire the connection. This type of network gives more flexibility and easily adapts the changes in the network configuration. But wireless network is more susceptible to interference due to other radio frequency devices, and obstruction. Total throughput is also decreased when there are multiple connections [17]. The wireless network gives freedom to the devices, for forwarding data and takes part in communication without networking cables, which increase the mobility but decrease the range of communication



1.3 Ad-hoc Network

A network without any fixed access point and also does not depend on pre-existing Infrastructure that's why such network is called Ad-hoc. Wireless Ad-hoc network is made up of few to hundred numbers of nodes or device that are connected through a Radio Frequency (RF) of infrared interface and have a capability of communicating with each other by making connected in a decentralized manner [19]. All mobile nodes of the network have equal importance means any node of the network can be work as a host or router and can communicate by transmitting the data directly to any node or device on the network [20]. The control of the network is also distributed to every node of the network. As in wireless system all nodes or devices on the network are connected through the radio transmission path and because of that they are easily affected by noise, fading and interference. The Ad-hoc network is depicted below.



Wireless Ad-hoc network is having a number of sensor node spreads over a specified area [19]. Each node has a capability of networking the data. Some
example of wireless ad-hoc network is as follows:

i) The network used to monitor the environment and detect environmental changes.

ii) The network used to detect and transmit data for military and defence purpose.

iii) Network used to sense and monitor vehicle traffic on the road.

iv) Network for surveillance sensor for providing security in any place.

v) Network for patient monitoring system to transmit data from ambulance to doctor and receive medical advice from a distance. If every nodes of the network are moving, then structure of the network changes continuously and connectivity may break due to node movement that creates unpredictable topology and link stability. To overcome the problem of decreasing performance mobility of node, routing protocol is very important necessity of mobile ad-hoc network. Routing protocol allows every device s or node to communicate over multi-hop paths to their intended node. Previously flooding mechanism is used to forward the data in MANET. Main requirement of ad-hoc network is very efficient routing protocol that's why routing protocol are getting attention by the researchers.

1.4 IEEE 802.11 WLAN Standard

IEEE standard 802.11 gives the physical layer and MAC specification for WLAN [8]. Which can be operated in 2.4, 3.6, 5, and 60 GHz band Internet protocol suite is a group of communication protocols used in networking. TCP(Transmission control protocol), and IP were networking protocols gives total connectivity and specifies how the data must be addressed, , routed ,transmitted and received at its destination node [21]. The functionality of protocols is organized in four layers: Link Layer, Application layer, Internet layer and Transport layer.

Link layer

Link layer can be defined as a group of methods and communication protocol that operate on the link, where operated node is physically connected. The link is any interconnecting component, which is used to interconnect nodes of the network and link protocol is a group of methods, which operate only between adjacent nodes of the network. Link layer can also be seen as the group of physical layer and datalink layer in OSI model.

Physical layer

This is first stage of the TCP/IP, where data is physically moved across the network interface.

Data link layer

It is a layer of TCP/IP model that forward data between adjacent nodes of the network over wide area network or transfer packet between nodes of the same WLAN [15]. It provides a functional way to transfer data between different nodes of network and also have a power to correct errors occur in physical layer. Ethernet of LAN protocol and Point to point

protocol are the example of data link protocols [22]. Data link layer is further subdivided into two basic layer:

i) Logical link control

ii) Media access control

i) Logical link control

This is the top most layer of data link layer. Its function is to assign addressing, and control data link layer. It select which method is used for addressing over transmission medium and controlling data exchange between nodes. This layer may provide flow control, acknowledgement and error notification.

ii) Media access control (MAC)

Its function is to determine which node is allowed to access the media at that instant of time [22]. Distributed and centralized are two forms of MAC. MAC sub layer also synchronize the frame of the data by determining where one frame of data end and next frame starts. MAC sub layer synchronize the data by four methods they are:

Time synchronization

Character counting

Byte stuffing

Bit stuffing

1.5 Related Work

In [6] routing protocols like TORA, AODV, DSR and DSDV are compared. It is demonstrated through re-enactment comes about that DSR produces lower routing burden compared to AODV. AODV experiences end to end postponement while TORA has high directing overhead. The better execution of DSR is on the grounds that it adventures storing forcefully and keeps up different courses to the destinations. Execution correlation of AODV and DSR protocols in an obliged circumstance is done in [24]. The creators assert that the AODV out-frames DSR in typical circumstance however in the obliged circumstance DSR out performs AODV, where the debasement is as extreme as 30% in AODV while DSR debases imperceptibly as 10%. An examination of Link State, AODV and DSR conventions for

two diverse movement classes, in a chose domain is done in [8].It is concluded that AODV and DSR perform well when the system burden is moderate and if the activity burden is substantial then basic Link State out-performs the responsive conventions . Perkins et all [10] demonstrate the execution of two on interest steering conventions specifically DSR and AODV. In spite of the fact that both AODV and DSR use on interest course disclosure, they have diverse steering mechanics. The creators watch that for application situated measurements, for example, delay, throughput DSR beats AODV when the quantities of hubs are littler. AODV outflanks DSR when the quantity of hubs is substantial. The creators do demonstrate that DSR reliably produce less steering burden than AODV.

2

Overview of MANET Routing Protocols

2.1 Introduction

Remote correspondence innovation have been created with two fundamental models one is fix establishment based on model in which a huge piece of the centres are convenient and joined through modified spine centre points using remote medium. Another model is MANET (Mobile Ad-hoc network) are incorporated MN(mobile nodes) that are self-dealing with and cooperative to guarantee powerful and accurate bundle steering amidst centres (and, perhaps, base stations). There will be no specific servers, switches, access focuses for MA-NETs. Because of its brisk and basic of game plan, quality, and simplicity, Typical MANETs applications could be find in the going hand in hand with reaches like protection applications (i.e. a transitory system in the combat zone), Search and rescue operations, Temporary frameworks within meeting rooms, air terminals, Vehicle-to-vehicle correspondence in sharp transportation, PAN (Personal Area Networks) uniting mobile phones like cell phones, con-venient PCs, clever watches, and other wearable PCs et cetera.

Setup issue for building up a steering convention for remote environment with versa-tility is out and out diverse and psyche boggling than those for wired framework with static hubs. Essential issue in mantes are Limited information exchange limit and habitus node change in the topology .Although there are piles of coordinating traditions that can be used for unicast and multicast correspondence within the Mobile Ad hoc frameworks, it watches that any one tradition can't fit in all the various circumstances, particular topologies and movement illustrations of Mobile Ad-Hoc Networks applications. A valid example, proactive directing traditions are to a great degree supportive for a little scale MANETs with high adaptability, while responsive directing convention are astoundingly important for an expan-sive scale, MANETs with moderate or less topology changes. Crossover directing convention attempts to strike amicability between the two, for instance, proactive for neighbourhood, re-ceptive for far away. Beside this multicast is another class of coordinating tradition in MA-NETs which capably support to the social event correspondence with the high throughput. The use of multi-tossing inside MANETs has various favorable circumstances. It can lessen the cost of remote correspondence and grow the profitability and throughput of the remote association be-tween two hubs at whatever point we are sending various copies of the same messages by accomplishment the normal TV properties of remote transmission. Set up of sending same information through numerous unicasts, multicasting decline channel limit uti-lization, sender nodes and switches handling, vitality usage , and information conveyance

delay, which are intentional essential for MANETs. On the off chance that the portable hubs in the MANET move too rapidly, they need to repair to telecast to accomplish node to node communications. Each directing convention has its favourable circumstances and disservices, and goes for a particular application. At long last, the normal standard for routing conventions in the Mobile Ad-Hoc Net-works is liable to consolidate probably the most competitor plans. Along these lines the objective for a directing convention is to minimize its control traffic overhead while in the meantime, it ought to be fit for link failure and addition caused by node movements.

2.2 Protocol Classification

Routing protocols normally can be categorized into two category initial one is multicast Routing Protocol, second one is unicast Routing Protocol. Distinctive routing protocols attempt to take care of the issue of directing in versatile specially appointed system in one way or the other. Unicast routing protocols can be categorized into proactive, receptive and hybrid routing protocol, and the routing protocol of multicasting are separated into proactive, reactive, and hybrid routing protocols. Figure below (Figure 1) gives an order on steering convention is in view of unicast and multicast directing convention. Proactive directing that implies course accessible promptly. Receptive directing that implies dis-covers the course when required. Also, crossover directing that implies blend of both, for example, proactive for neighbourhood, reactive for far away.

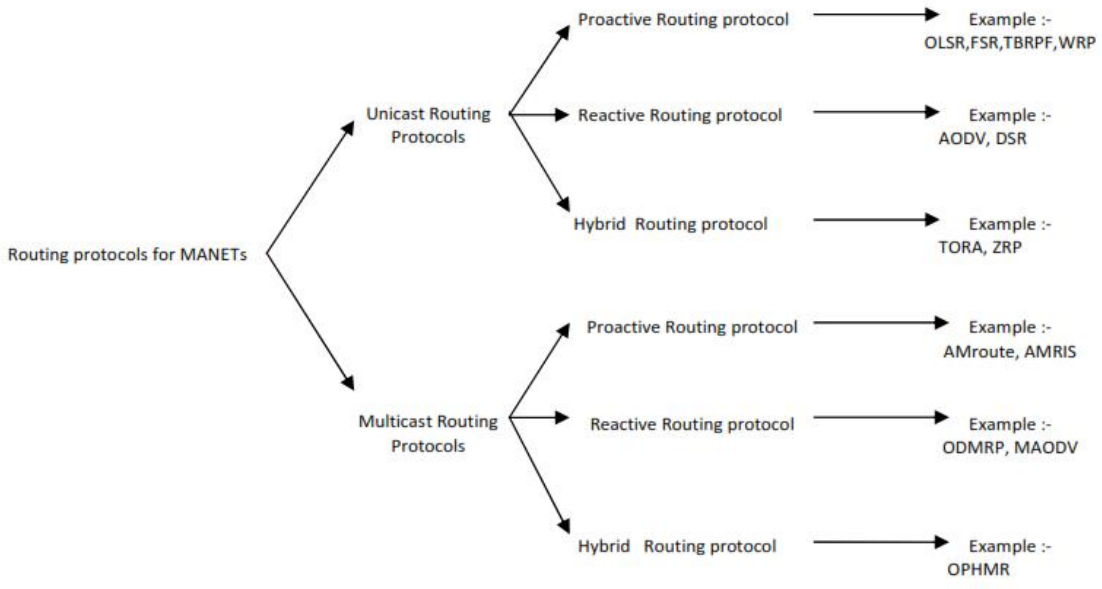


FIGURE 1: Classification on routing Protocols for MANETs

2.2.1 Unicast Routing Protocol

Most networks in the MANET are based upon unicasting. In this way, the most key operation in the internet protocol layer of the mobile adhoc network is to adequately transmit packets of data from one source to the destination. The sending system is incredibly fundamental in itself with the coordinating table the hand-off centres just uses the address of the destination in the data package to discover it in the routing table. If the longest organizing destination area is found in the table, the bundle is sent to the contrasting next bob. The issue that develops is the way by which the coordinating table is amassed in the centres in the MANET [1]. Figure 2 below shows the unicast process. In the unicast guiding one distinctive copy sends to each gatherer from the source canter point. Data package is replicated at the sender centres and after that passed on to each destination centre. By this methodology we can without quite a bit of a stretch see that information exchange limit is eaten up by the overabundance data packages. Various systems use the unicast routing protocol tradition according to the need of the application. There are proactive, open and creamer coordinating tradition in unicast guiding for Mobile dispersed frameworks..

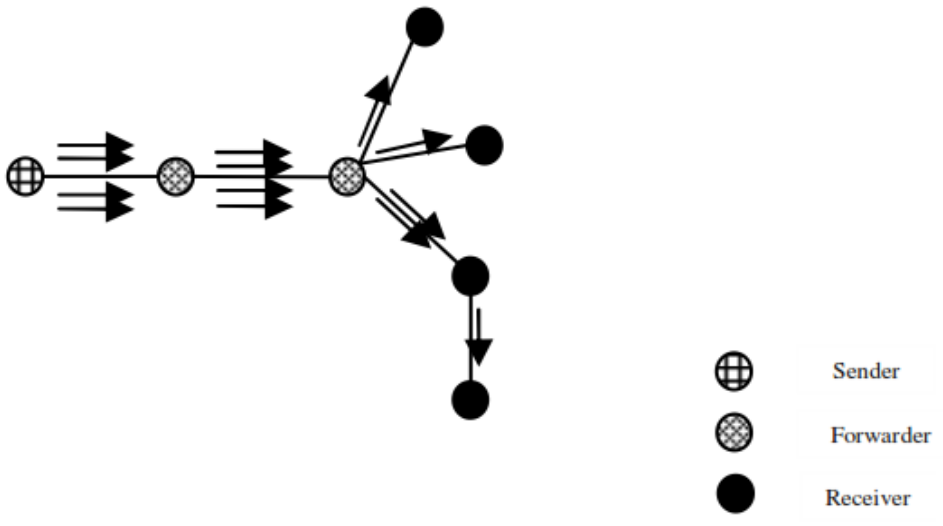


FIGURE 2: Unicast: Data Packet is replicated at the sender

2.2.1.1 Proactive Unicast Routing Protocols

Conventional routing protocols, for example, OLSR(Optimized link state routing protocol),FSR (Fisheye State Routing) and TBRPF (Topology Broadcast Based on Reverse-Path Forwarding Routing Protocol) are unicast routing protocols. Intermittent show of system topology upgrades (e.g., separation vector or connection state data) is necessary to process the briefest way from the source to each destination, which expends a great deal of transfer speed. Despite the fact that they are broadly utilized as a part of the Internet spine. They can't be utilized as a part of the MANET straightforwardly due to the contrasts between the hard-wired system and the MANET.

A. Optimized Link State Routing Protocol (OLSR)

OLSR (Optimized link state routing protocol) [5] is a proactive table-driven routing protocol for mobile adhoc networks. Whenever there is a requirement of path between any node , it could easily get from routing table. OLSR is taking into account the connection state calculation. Traditionally, every remote hub surge neighbour data in a connection state convention, yet not in OLSR hub. It is publicizing in-development just about connections with neighbour who is in its multipoint hand-off group. Its lessen size of packet control bundles diminishes flooding by utilizing just multipoint transfer nodes to send or receive information in the system and decrease number of control packet overhead by decreasing copy broadcasting. This convention does not expect solid exchange, since overhauls are sent occasionally. OLSR utilized jump by-bounce directing. Courses are in view of element table sections kept up at in-terminate hubs. The convention is configuration to work in appropriated way and therefore does not de-pend up on the focal substance. The conventions in this way bolster a node versatility that can be followed through its neighbourhood control message, which depends up on the recurrence of these messages. Advertisement vantage of OLSR is having the courses accessible inside of the standard steering table can be helpful for a few frameworks and system applications as there is no course revelation delay associated with discovering another course. Greater overhead and need more power are primary burden of this convention.

B. Better Approach To Mobile Adhoc Networking (B.A.T.M.A.N.)

The Better Approach To Mobile Adhoc Networking (B.A.T.M.A.N.) is a routing protocol for multi-bounce specially appointed systems which is a work in progress by the "Freifunk" group and expected to supplant OLSR. It can be utilized for lattice arranges yet this is not by any means the only potential utilization. B.A.T.M.A.N's. critical point is the decentralization of the information about the possible best course through the system — none of the node has all the information. This method wipes out the need to spread data concerning system changes to each hub in the system. The individual hub just spares data about the "bearing" it got information from and sends its information likewise. Therefore the information gets went on from hub to hub and bundles get individual, rapidly made courses. A system of aggregate knowledge is made. B.A.T.M.A.N. has components of established steering conventions: It recognizes other B.A.T.M.A.N. nodes and discovers the most ideal route (course) to these. It additionally stays informed regarding new hubs and illuminates its neighbours about their presence. In static systems, system heads or experts choose which PC is come to by means of which way or link. As radio net-works experience consistent changes and low cooperation edges are a crucial piece of the "Frei-funk"-systems' establishment this errand must be computerized quite far. On a general basis, each hub conveys a telecast along these lines advising every one of its surrounding about its presence. The surrounding nodes then handoff this message to their surrounding etc. This conveys the data to each hub in the system. Keeping in mind the end goal to locate the most ideal path to a certain hub, B.A.T.M.A.N tallies the originator-messages got and logs which neighbour the message came in through. Like separation vector conventions, B.A.T.M.A.N never not attempt to focus the entire way, but rather, by utilizing the originator-messages, just the bundle's initial phase in the right bearing. The information is given over to the following neighbour in that heading, who thusly utilizes the same instrument. This procedure is rehashed until the information achieves its destination.

C. Fisheye State Routing Protocol (FSR)

The FSR (Fisheye State Routing) [12] is a table driven unicast directing convention for manets in view of Link State steering calculation essentially with diminished overhead to keep system topology content. As name suggest, FSR uses a capacity like a fish eye. As we

know eyes of any fishes catch the pixels close to the central with high detail, and the point of interest reductions as the separation from the point of convergence increments. Like fish eyes, FSR keeps up the precise separation and way quality data about the prompt neighbouring hubs, and dynamically lessens detail as the separation increments. Point of interest of this convention is that it has probability to bolster various way directing and QoS steering yet detriment of FSR is that it has high stockpiling multifaceted nature.

D. TBRPF (Topology Broadcast Based on Reverse-Path Forwarding Routing Protocol

It is a topology telecast taking into account Reverse-Path Forwarding Routing Protocol was proposed in [11]. TBRPF goes for the (MANET) Mobile Ad hoc Network with at most a couple of many versatile centre points or high movability of hubs. Every centre in the remote framework keeps mostly overall topology information. Exactly when a centre point needs the briefest path to one another centre, a base intersection tree set up at itself is prepared using balanced Dijkstra's estimation. TBRPF transmits only the differentiations between the past framework state and the present framework state. In this way, directing messages are smaller, and can likewise be sent all the more every now and again. This infers that hubs directing tables are all the more uncommon.

2.2.1.2 Reactive Unicast Routing Protocols

For the changing topology of the Mobile Adhoc Network, the worldwide topology data put away at every hub needs to be redesigned much of the time, which devours heaps of transfer speed. Then again, this utilization once in a while is a misuse of data transfer capacity, on the grounds that the connection state overhauls got lapse before the course in the middle of itself and another hub is required. To reduce the wastage of data transmission to its minimum On Demand or reactive routing protocol has been proposed in [13].In case of On Demand conventions; the directing is isolated into the accompanying two stages: initial one is course disclosure and second one is course support. The most commonly used On Demand unicast directing conventions are DSR, AODV and Temporally Ordered Routing Algorithm and so forth.

A. DSR (Dynamic Source Routing Protocol)

DSR (Dynamic Source Routing) [2] is an On Demand unicast routing protocol that uses source directing calculation. In case of source directing calculation, every information bundle contains complete directing data to achieve its spread. Furthermore, in DSR every node uses storing innovation to keep up course data that it has found. For instance, the intermediate hubs reserve the path towards the destination point and in reverse to the source. Besides, in light of the fact that the information bundle contains the source route in the header, the catching nodes are able to reserve the course in its directing store.

B. AODV (Ad Hoc On-demand Distance Vector Routing Protocol)

AODV [3] is a reactive unicast directing convention for portable specially appointed systems. As a responsive directing protocol, AODV just needs to keep up the steering data about the dynamic ways. In AODV, directing in-development is kept up in steering tables at hubs. Each portable node responsible to keeps tab ona next-bounce defeating table, which could contain the destinations to which it presently has a course. A directing table passage lapses in the event that it has not been utilized or reactivated for a pre specified close time. Moreover, AODV embraces the destination grouping number strategy utilized by DSDV as a part of an on-interest way.

C. Temporally Ordered Routing Algorithm

Temporally Ordered Routing Algorithm (TORA) [16, 17] is an On Demand directing algorithm taking into account the idea of connection inversion. This Routing convention enhances the halfway connection inversion strategy by recognizing parcels and halting non-profitable connection inversions. TORA can be utilized for profoundly dynamic portable specially appoint1ed systems. TORA has three fundamental steps: course creation, course support and course eradication. In TORA the DAG gives the ability that numerous hubs can send parcels to a given destination and assurances that all courses are sans circle. Due to hub portability the DAG in TORA may be separated. So the route maintenance step is a vital piece of

TORA. This directing convention has the extraordinary highlight that control messages are restricted into a little arrangement of hubs close to the topology changes occurred.

2.2.1.3. Hybrid Unicast Routing Protocols

Hybrid routing protocol endeavours to find harmony between the two, for example, proactive for neighbourhood, responsive for far away. In perspective of proactive and responsive guiding conventions, some hybrid coordinating traditions are proposed to unite their great circumstances. The most particular routing and coordinating tradition is Zone Routing Protocol.

A. Zone Routing Protocol (ZRP)

ZRP (Zone Routing Protocol) [4] is a partial active and partially proactive routing protocol for versatile conditional environments. The crossover conventions are suggested to diminish the control overhead packets of proactive steering methodologies and lessening the inactivity brought on by course look operations in responsive routing methods. Zone Routing Protocol (ZRP) is a structure of mixture routing suites, which is designated by the accompanying modules: First one is the Intra-zone Routing Protocol, second one is the Inter-zone Routing Protocol, and Broadcast Resolution Protocol. ZRP alludes to the provincially proactive steering part as the Intra-zone Routing Protocol (IARP). The universally responsive directing segment is named Inter-zone Routing Protocol (IERP). IERP and IARP are not particular directing conventions. Rather, IARP is a group of constrained profundity, proactive connection state directing conventions. IARP keeps up steering data for hubs that are inside of the directing zone of the hub. IERP is a group of responsive directing conventions that offer upgraded course revelation and course support administrations in view of neighbourhood network observed by IARP.

2.2.2 Multicast Routing Protocols

In spite of the fact that multicast transmission has not been broadly conveyed in their recent mobile adhoc network, it will turn out to be vital in mixed media correspondences soon. To send a same information bundle to numerous collectors in the MANET all the while, the most straightforward strategy is to telecast the information bundles. Nonetheless, telecast devours extensive data transmission and pow-er, which ought to be maintained a stra-

tegic distance from however much as could reasonably be expected. Multicast can be used for recovery the transmission capacity while continually transmitting same information parcels to various beneficiaries .Figure 3 demonstrates the multicast star cess, information parcel is recreated by the system. There are numerous multicast routing protocols for MANET. They could be separated into three gatherings: initial one is proactive multicast, then reactive multicast and last one is half reactive and half proactive multicast routing protocols.

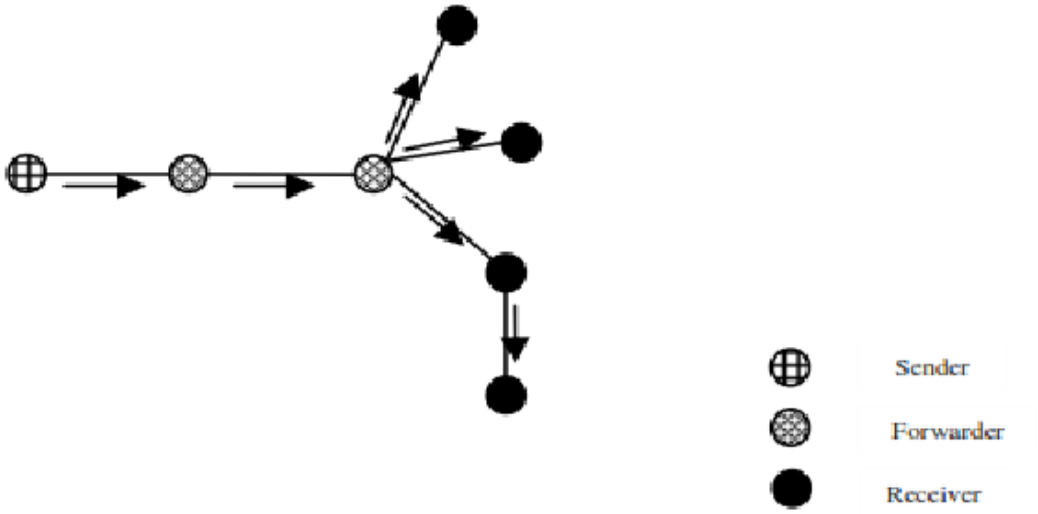


FIGURE 3: Multicast: Data packet replicated by the network

2.2.2.1 Proactive Multicast Routing Protocols

Traditional routing protocols, for example, AM Route (Ad-hoc Multicast Routing), CAMP (Core-Assisted Mesh Protocol) and AMRIS (Ad-hoc Multicast Routing Protocol Utilizing Increasing id-numbers) are proactive multicast routing protocols by nature. Occasional telecast of system topology overhauls are expected to register the briefest way from the source to each destination, which devours a great deal of transmission bandwidth.

A. Ad-hoc Multicast Routing (AM Route)

Specially appointed Multicast Routing (AM Route) is a tree based multicast routing protocols for versatile impromptu systems. AM Route makes a multicast shared based tree over lattice. AM Route depends on the presence of a hidden unicast steering convention. AM Route has two primary stages: tree creation and network creation. This convention can be utilized for systems as a part of which just an arrangement of hubs backings AM Route directing capacity. It is one and only coherent centres in the multicast tree, which is in charge of gathering part support and multicast tree creation. In this defeating convention fabricates a client multicast tree, in which just the gathering individuals are incorporated; be-cause non-individuals are excluded in the tree, the connections in the tree are virtual connections. As such, they are indeed multi-bounce IP-in-IP passages and AM Route relies upon the basic unicast directing convention to manage system flow, despite the fact that it has no benefit for unicast steering conventions. AM Route makes a proficient and vigorous shared tree for every gathering. It helps to keep the multicast conveyance tree unaltered with changes of system topology, the length of ways between tree individuals and centre hubs exist through lattice joins. At the point when versatility is available, AM Route experiences circle development, makes no ideal trees, and requires higher overhead to appoint another centre. Likewise, AM Route experiences a solitary purpose of disappointment of the centre node.

B. Ad hoc Multicast Routing Protocol Utilizing

Specially appointed Multicast Routing (AM Route) is a tree based multicast directing convention for versatile impromptu systems. AM Route makes a multicast shared-tree over lattice. AMRoute depends on the presence of a hidden unicast steering convention. AM Route has two key stages: network creation and tree creation. This convention can be utilized for systems as a part of which just an arrangement of hubs backings AM Route directing capacity. It is one and only coherent centres in the multicast tree, which is in charge of gathering part support and multicast tree creation. In this defeating convention fabricates a client multicast tree, in which just the gathering individuals are incorporated; be-cause non-

individuals are excluded in the tree, the connections in the tree are virtual connections. As such, they are indeed multi-bounce IP-in-IP passages and AM Route relies on upon the basic unicast directing convention to manage system flow, despite the fact that it has no benefit for unicast steering conventions. AM Route makes a proficient and vigorous shared tree for every gathering. It helps keep the multicast conveyance tree unaltered with changes of system topology, the length of ways between tree individuals and centre hubs exist through lattice joins. At the point when versatility is available, AM Route experiences circle development, makes no ideal trees, and requires higher overhead to appoint another centre. Likewise, AM Route experiences a solitary purpose of disappointment of the centre node.

C.CAMP (Core-Assisted Mesh protocol)

It is a proactive multicast steering convention in light of shared cross sections. The lattice structure gives no less than one way from every source to every beneficiary in the multicast bunch. It depends on a fundamental unicast convention which could give the right separations to all destinations inside limited time. Each hub keeps up a RT that is made by the fundamental unicast steering convention. This routing table can be altered by CAMP . A Multicast Routing Table (MRT) is in light of the Routing Table that contains the arrangement of known gatherings. Additionally, every part hub keep up an arrangement of reserves that contain beforehand seen information bundle data and unacknowledged participation demands. The creation and upkeep of lattices are fundamental parts of CAMP.

2.2.2.2 Reactive Multicast Routing Protocols

Example of reactive multicast routing protocols is On-Demand Multicast Routing Protocol (OD-MRP) and Multicast Adhoc on-interest Distance Vector (MAODV).These protocols find the route on requirement due to reactive nature .These types of routing protocols are appropriate for large scale network of manet.

A.On-Demand Multicast Routing Protocol (ODMRP)

It is a responsive cross section based multicast routing protocol. ODMRP is a multicast routing protocol with unicast directing ability. The source builds up and keeps up gathering participation and multicast work on interest on the off chance that it is required to send information bundles to the multicast group, which is to some degree like MAODV. An arrangement of nodes, which is called sending gathering, take part in sending information bundles among gathering individuals. Each and every states in ODMRP are precise states, which are invigorated by the control messages specified above or information bundles, which accomplishes higher heartiness. ODMRP utilizes a sending gathering idea for multicast bundle transmission, in which each multicast bunch G is connected with a sending gathering. A hub in forwarding group are responsible for sending multicast parcels of gathering G. Multicast gathering of ODMRP, the source responsible to manage the gathering participation, sets up and redesigns the multicast courses on interest. Like reactive unicast steering conventions, ODMPR involves two principle stages: the solicitation stage and the answer stage .Whenever a multicast transmitter has a parcel to transmit yet it will have no directing and gathering enrolment data, it surges a Join Request bundle to the whole system. Join Request parcels are part publicizing bundles with piggybacked information payload. At the point where a hub receives a non-copy join request, it will save the upstream node number in its routing table and rebroadcasts the bundle. At the point when the JOIN Request bundle achieves a multicast recipient, the receiver revives or makes a passage for the originator in Member Table and shows JOIN TABLE bundles intermittently to its neighbours. At the point when a hub gets a JOIN TABLE bundle, it checks every section of the table to see whether there is a passage inside the table whose next node ID field must be same as its original ID. In the event that there is a match, the hub perceives that it is on the way to the source, hence it is a piece of the sending gathering. At that point it sets the FG_FLAG and shows its own particular JOIN TABLE based upon coordinated passages. Therefore, every individual from a sending gathering engenders the JOIN TABLE parcels until the multicast source is come to through the most brief way. This procedure builds (or redesigns) the courses from originator to recipients and fabricates a cross section of nodes, the sending gathering.

B. Multicast Ad-hoc On-demand Distance Vector (MAODV)

Multicast operation of Ad-hoc On-interest Distance Vector (MAODV) is a responsive tree-based multicast directing convention. MAODV is an augmentation of the unicast directing convention Ad-hoc On-interest Distance Vector (AODV). Utilizing MAODV, all hubs in the system keep up nearby integration by TV "Hi" messages with TTL set to one. Each hub keeps up three tables, a Routing Table (RT), a Multicast Routing Table (MRT) and a Request Table. RT stores steering data and has the same capacity as in AODV. In unicast directing operations, each destination has an interesting arrangement number. In like manner, each multicast assemble likewise has a grouping number to show the freshness of the multicast steering data. In this way, unrivalled one gathering pioneer is chosen to show periodical GROUP HELLO messages all through the MANET to keep up the grouping number. The gathering pioneer is of course the first hub joining the gathering, yet could likewise be another hub when the first hub leaves the gathering. The principle downsides of MAODV are long defers and high over-heads connected with settling softened connections up states of high portability and activity load. Al-along these lines, it has a low parcel conveyance proportion in situations with high portability, vast quantities of members, or a high activity load. Due to its reliance on AODV, MAODV is not adaptable.

2.2.2.3. Hybrid Multicast Routing Protocols

Routing protocol such as Optimized Polymorphic Hybrid Multicast Routing Protocol (OPHMR) is a hybrid multicast directing convention. Crossover directing convention attempts to find harmony between the two, for example, proactive for neighbourhood, receptive for far away.

A. Optimized Polymorphic Hybrid Multicast Routing Protocol (OPHMR)

This convention is contributed with diverse operational modes that are either proactive or receptive in light of a MN's energy remaining portion, portability level, and region thickness level. It at-entices to address the issues of force productivity, inactivity, and convention overhead in an adaptive way. OPHMR's receptive conduct is taking into account the On Demand Multicast Routing Protocol (ODMRP). It's moderately oversimplified. It creates on-interest course ways for multicast message demands. OPHMR's proactive conduct is in view of the Multicast Zone Routing (MZR) convention. It fabricates a zone around every Mobile Node (in bounces) and occasionally sends upgrades inside of each characterized zone. For included proficiency, OPHMR uses a streamlining plan adjusted from the Optimized Link State Routing (OLSR) convention. It used to abatement the measure of control overhead that is created. OPHMR is, after an extremely long time of time, ready to augment battery life and improve the survivability of the portable impromptu nodes. Subsequently, it diminishes the end-to-end postpone and expands the packet delivery ratio.

3

Overview of NS3

3.1 Introduction to ns3

ns-3 is a discrete-event network simulator, focused on fundamentally for examination and educational use. ns-3 is free software, authorized under the GNU GPLv2 permit, and is freely accessible for examination, advancement, and utilization. The objective of the ns-3 venture is to build a open simulation environment for networking research. It ought to be adjusted to the needs of present day network systems administration examination and ought to support community contribution and associate audit.

The ns-3 task is focused on building a strong simulation core that is very much documented easy to use and debug and that caters to the needs of the entire simulation workflow, from simulation configuration to trace collection and analysis. Besides, the ns-3 product base energizes the improvement of simulation models which are adequately practical to permit ns-3 to be utilized as a real time system emulator, interconnected with this present reality and which permits numerous current true convention executions to be reused inside ns-3.

The ns-3 simulation core backings inquire about on both IP and non-IP based systems. Then again, the expansive lion's share of its clients concentrates on wireless/IP simulation which includes models for Wi-Fi, WiMAX, or LTE for layers 1 and 2 and a mixture of static or dynamic steering conventions, for example, OLSR and AODV for IP-based applications.

ns-3 likewise underpins an ongoing scheduler that encourages various "reproduction tuned in" utilization cases for cooperating with genuine frameworks. For example, clients can discharge and get ns-3-produced bundles on genuine system gadgets, and ns-3 can serve as an interconnection structure to include connection impacts between virtual machines.

3.2 NS3 Languages

NS3 is working on two key languages that are C++ and Object oriented Tool Command (OTCL).Both the languages have the own benefits like, OTCL runs slowly but easy to code whereas coding of C++ is difficult but execution is fast. NS3 utilizes benefits of both the languages so that anyone can vary the parameter and configure network very easily. The internal program is written in C++ whereas OTCL is used for assembling and configuring the object and scheduling discrete events. The C++ and OTCL are combined by using Tcl CL after simulation and for getting the result graphically; Network Animator (NAM) and Trace

file analyser is used. NAM (Network Animator) is an animation tool for NS3 used to visualize the network and packet of information tracing and Trace file (.tr) contains the overall network simulation information.

3.4 Steps For Getting Trace And NAM Files

In NS3, the steps for getting trace and NAM files after the simulation are as follows:

i) Writing of the program in Object Oriented Tool Command Language (OTCL) language. OTCL is used to write the program for generate a network, network environment, and trajectory of mobile nodes.

ii) Run the **.tcl** file on the terminal under the Linux mint platform.

iii) NS3 trace analyser is use to analyses trace file obtained during simulation and according to trace file generate the respective graphs. Performance evaluation of different routing protocol is done on Network Simulator (NS3) which is installed on Oracle VM virtual box under the Linux mint platform. NS3 is a free simulator which provides the facility to set up network topology, configure and optimize the parameter according to the need of the application.

3.5 Simulation Parameters

3.5.1 End to end delay (Td)

This performance parameter represents an average delay and indicates the time taken by data bits to travel from source to intended node [14]. It include all delay caused by transmission at MAC, queuing at interface queue, processing and propagation delay. End to end delay is shown by equation below.

T_{ee} = Processing Delay (T_p) + Queuing Delay (T_q)+ Transmission delay (T_t) +Propagation delay (T_{pr})

3.5.2 Throughput

It represents the average rate of data packet received at the intended node. It is also defined as the total data packet reached at the intended node to the total time require by the bits of a data to reach the destination. Higher value of throughput means routing protocol is performing better, and throughput is given by equation below

$$Throughput = \frac{N \times P_s \times 8}{T_s}$$

Where,

N = Number of delivered packets
P_s = Packet size
T_s = Total duration of simulation

3.5.3 Packet Delivery Ratio (PDR)

It represents packet delivery ratio in percentage and indicates the ratio of packet of data received at intended node to the packet generated by the source The protocol will perform better, when the value of PDR is more.

$$PDR = \frac{\text{Number of packet received}}{Number\ of\ packet\ send} \times 100$$

3.5.4 Constant bit rate (CBR)

CBR indicates that the data are sent at constant rate and CBR data stream implies that the data is sending in a packet of fixed size with uniform interval.

3.5.5 Protocol Control Overhead

It is the ratio of amount of control packets transmitted to the number of data packet transmitted

3.5.6 TCP (Transmission Control Protocol)

TCP is one of the main protocols in **TCP**/IP networks. It is a connection based, and conforming transport protocol. Whereas the IP protocol deals only with packets, **TCP** enables two hosts to establish a connection and exchange streams of data. **TCP** guarantees delivery of data and also guarantees that packets will be delivered in the same order in which they were sent.

Flow control works to avoid overloading at the intended node

Congestion control is works to shape the traffic according to available network capacity.

The sender of TCP data is maintaining two windows for each intended node: a receive window represents the accessible capacity of the network and Congestion window defines the bounds of the receiver ability. When the sender transmits a packet of information, the windows are reduced by an amount same as the size of information sent, when any of windows reaches completely filled state.

4

Simulation and Results

4.1 Comparison between OLSR, ADODV, DSDV, OLSR and DSR Protocol

In this simulation I have considered the AODV, DSDV, OLSR and DSR conventions through the key measurements like Packet Delivery Ratio, Average end-to-end deferral, Throughput and Protocol Control Overhead .I have depicted those specific parameters in section 3. Be that as it may, before that the essential contrasts in these convention execution lies in the components they took after as per directing methodology based characterization as receptive and proactive proto-cols. In Reactive or on-interest steering courses are just found when they are really required. Thus, a hub that needs to send a bundle to another hub, the responsive conventions looks for the course in an on-interest premise and sets up an association with transmit and receive a parcel. The course revelation ordinarily comprises of system wide flooding of solicitation message. Interestingly, in proactive directing every hub persistently keeps up course between pair of hubs. Consequently, course creation and upkeep is expert through some mix of occasional and occasion activated steering redesigns got from separation vector or connection state technique. Both these methodologies have a few points of interest and additionally a few detriments and can be dissected from its execution measurements as examined in next segment. In this reproduction, I concentrated on AODV and DSR as receptive convention and DSDV and OLSR as connection state proactive convention.

4.2 Simulation Setup

In this work discrete-event simulator NS3 (version 3.13) .There are several models available in NS3 simulator, from which, the considered models:

(i) Node Model for energy source, memory capacity, processing capabilities etc.,

(ii) Node deployment model

(iii) Node mobility model

(iv) Radio Model

(v) Wireless Signal Propagation Model

(vi) Packet loss model

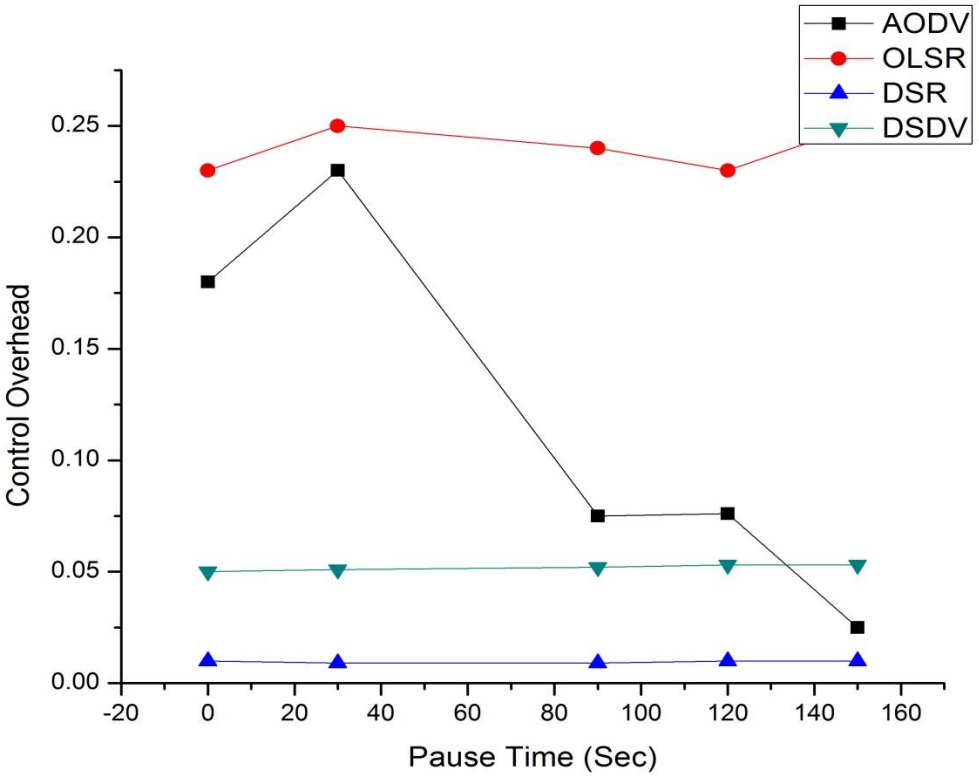
The simulation period for every scenario is 200 seconds and the simulated mobility network area is 1000*1000 square metre rectangular areas. For every scenario, the nodes are initially located at a random place inside the region. The MAC layer protocol is IEEE 802.11

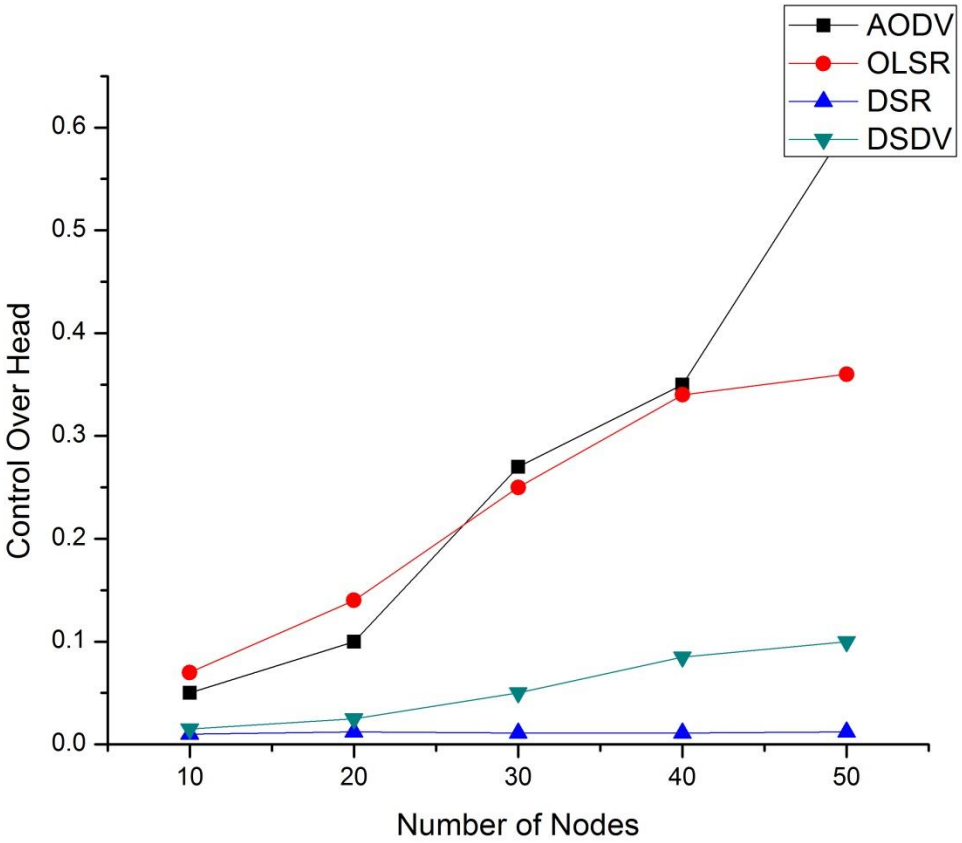
with packet size 500 bytes. The transmission range is 250m. The application used to generate is CBR traffic and IP is used as Network layer protocol. I have selected the Packet Delivery Ratio, Average end-to-end delay and Protocol Control Overhead as performance metrics during the simulation in order to evaluate the Performance of the different routing protocols.

4.3 Results and Analysis

First, an attempt was to compare the protocols under the same simulation environment. For each scenario, the same movement models were used, time of the simulation fixed to 50 seconds the maximum speed with random mobility of nodes was set to 10m/s and the pause time for varying nodes was 30 seconds. For first simulation, randomly generated 10 scenarios are considered by 10 simulation runs for each sample point of a particular protocol and average value of the result are used in the graphs of performance by a network by increasing the number of nodes from 10 to 50

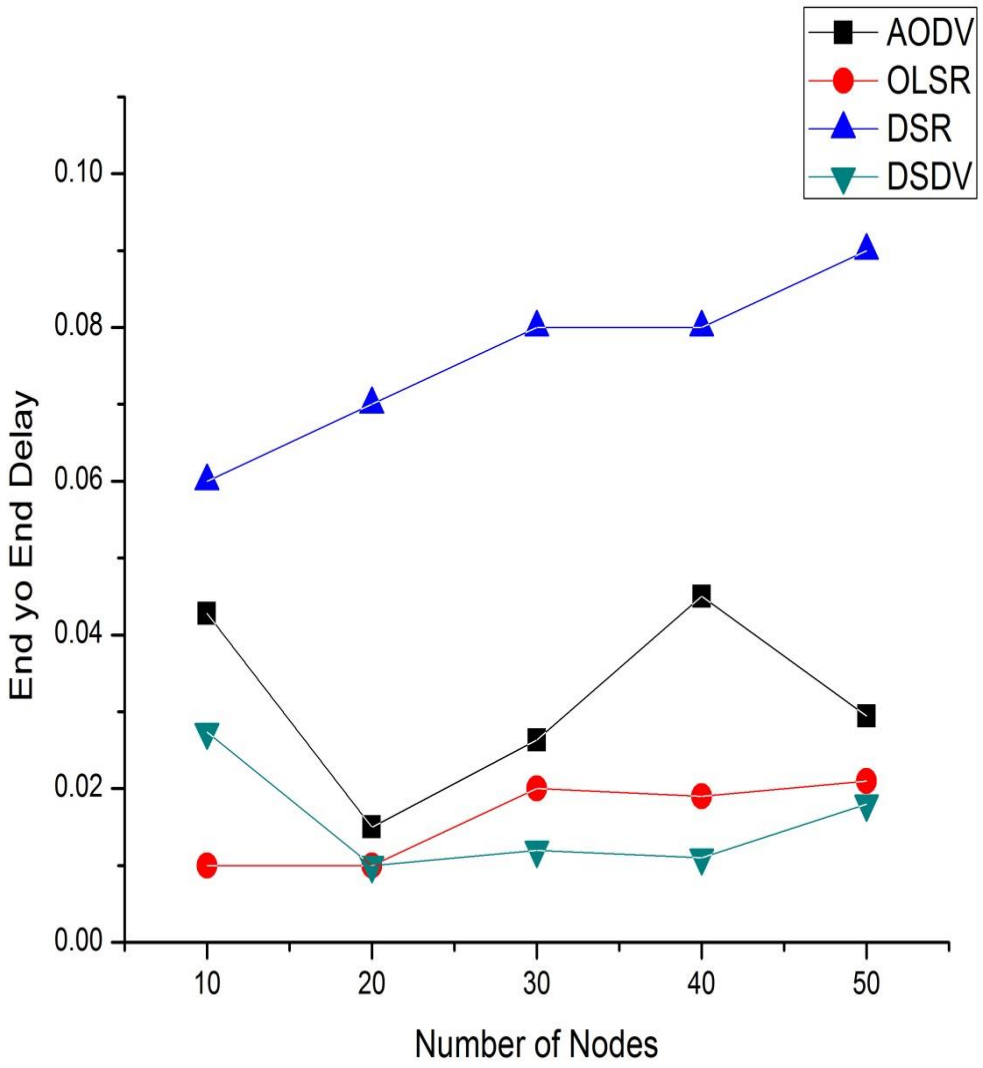
4.3.1Protocol Control Overhead

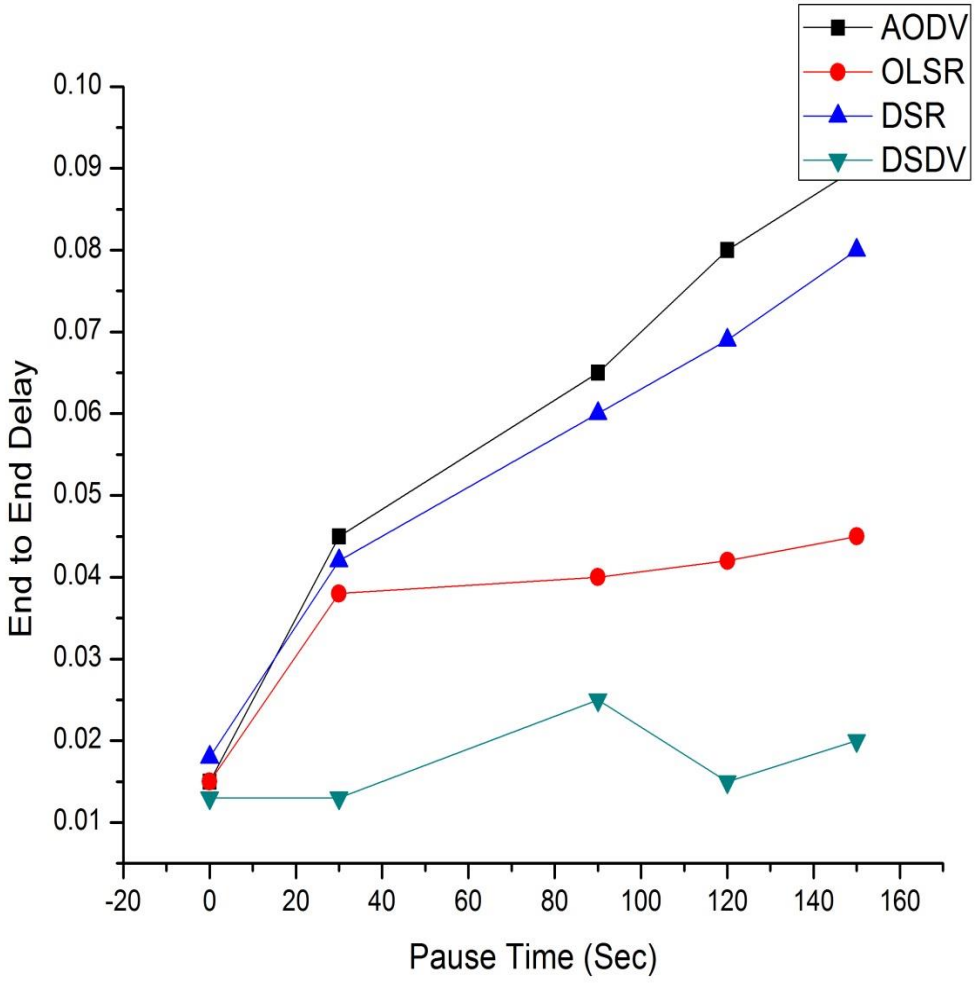

AODV
OLSR
DSR
DSDV
Control Overhead
0.25
0.20
0.15
0.10
0.05
0.00
-20
0
20
40
60
80
100
120
140
160
Pause Time (Sec)


AODV
OLSR
DSR
DSDV
Control Over Head
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10
20
30
40
50
Number of Nodes

As expected control overhead is most extreme if there should be an occurrence of OLSR convention. It is a connection state directing convention and connection state steering obliges topology database to be synchronized over the system. OSPF and IS-IS perform topology flooding utilizing a solid calculation Such a calculation is exceptionally hard to outline for impromptu remote systems, so OLSR is not that much dependable; it essentially surges topology information frequently enough to verify that the database will never stay unsynchronized for developed times of time. Element source directing proto-col (DSR) is an on-interest convention intended to confine the transfer speed devoured by control bundles in specially appointed remote systems by taking out the intermittent table-upgrade messages in the table-driven methodology. The real distinction in the middle of this and the other on-interest steering conventions is that it is reference point less and consequently does not require occasional hi bundle (signal) transmissions, which mostly are utilized by a node to advise its surroundings about its presence. For DSDV steering data is disseminated between hubs by sending full information base rarely and littler incremental upgrades or changes all the more oftentimes. AODV protocol performs Route Discovery utilizing control messages course request(RREQ) and course re-ply(RREP),whenever hub wishes to send bundle to destination. To control arrange wide show of RREQs, the source hub utilizes a growing ring pursuit strategy. The forward way sets up in moderate hubs in its course table with a lifetime affiliation utilizing RREP. At the point when either destination or halfway hub moves, a course slip (RERR) is sent to the affected source hubs. At the point when a source hub gets the (RERR), it can reinitiate the course discovery if the course is still required. Neighbourhood data is gotten from telecast Hello parcel. Likewise different Route Reply bundles because of a solitary Route Request parcel can prompt overwhelming control overhead So the quantity of directing overhead parcels will dependably be high unless courses quit evolving

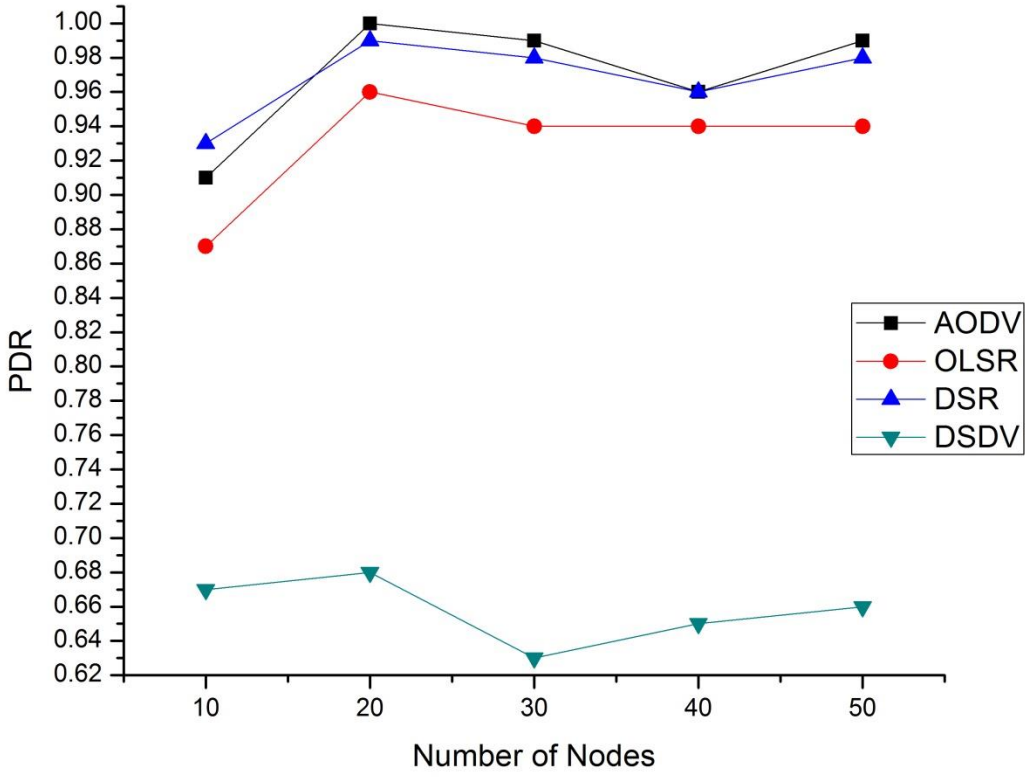
4.3.2 End to End delay

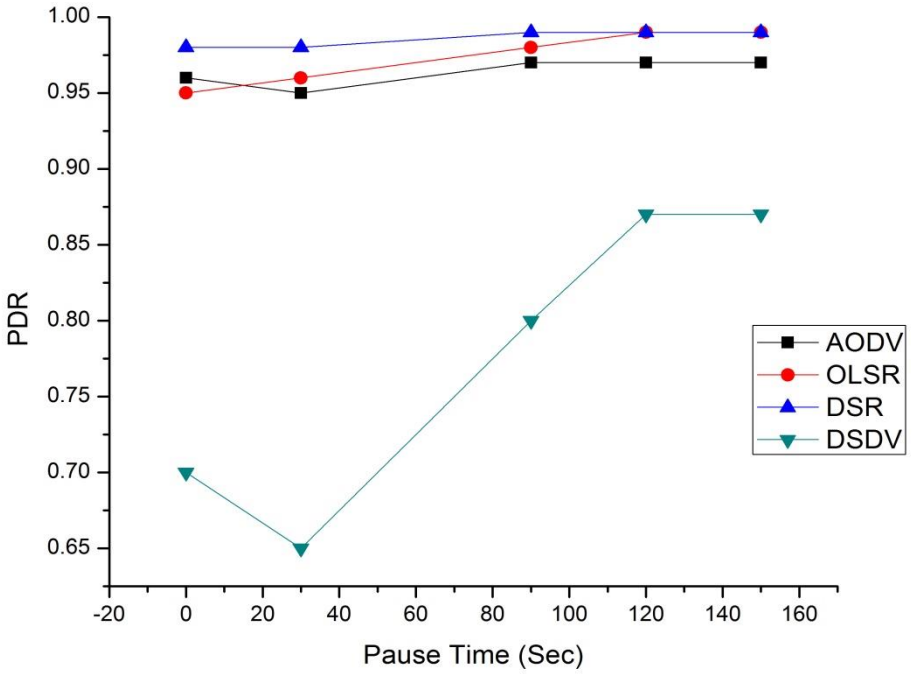




With increasing node DSR shows highest delay due to caching mechanism of DSR. The primary disadvantage of this protocol is that the route maintenance mechanism does not locally repair a broken link. Another reason for inconsistencies could be the state route cache information for the reconstruction phases. Connection setup delay is lower than in case table-driven protocols than DSR. It is safe to conclude than DSDV has the shortest End-to-End delay compared to AODV and DSR, because DSDV is a proactive protocol i.e. all routing information's are already stored in table. Hence, it consumes lesser time same also goes for OLSR.AODV and DSR show large delay in both the cases due to their reactive nature to build route when needed or requested

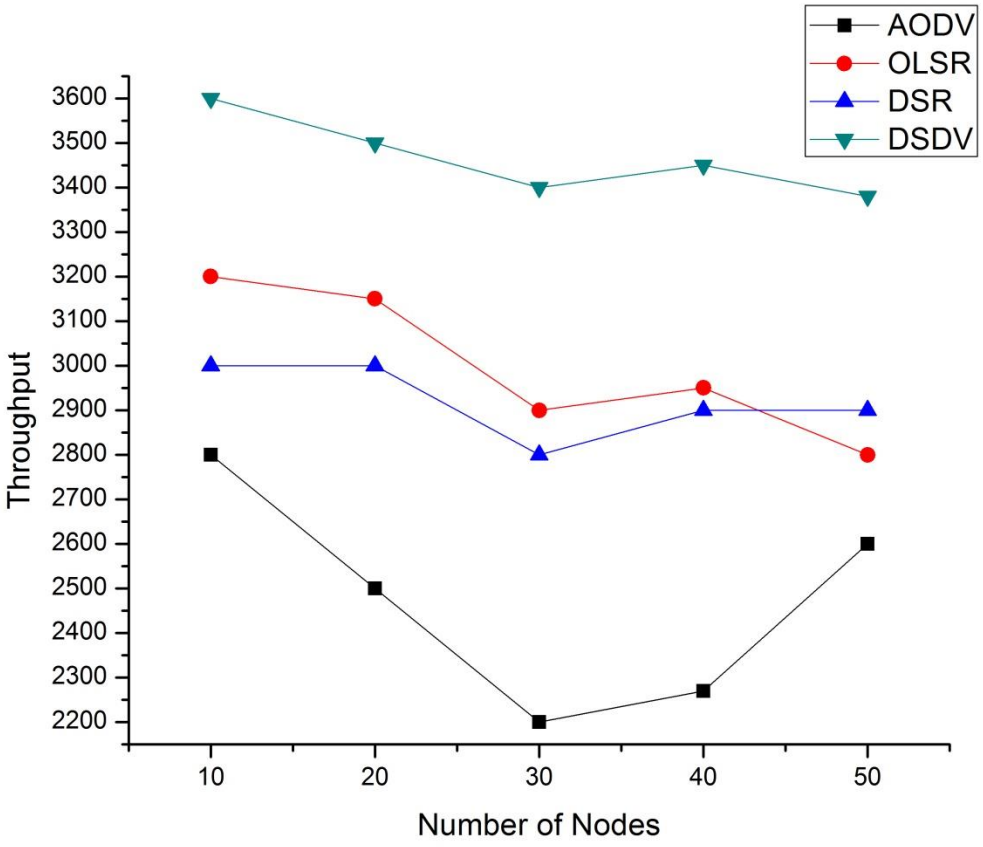
4.3.3 PDR (packet delivery ratio)

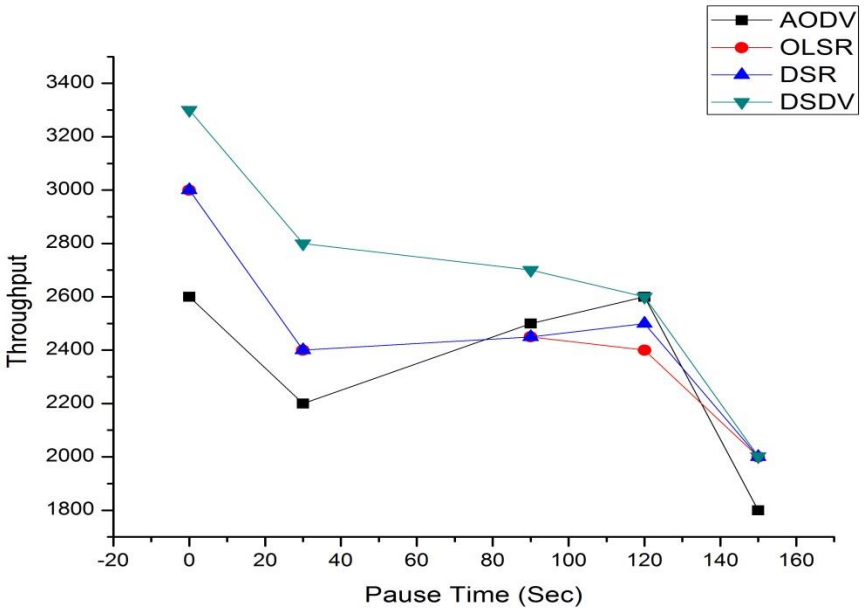




PDR of DSDV protocol always performed worst as shown in the above output due to routing loop problem. Where AODV and DSR performs comparable better in both the cases and OLSR also shows satisfactory results when steadiness of the network increases.

4.3.4 Throughput with varying nodes





AODV and DSR shows lowest throughput in both the cases due to their reactive nature. As route creation and data transfer consume time due to collective computations. In case of DSR data packet carries the complete path to be travelled, which is known as source routing. In case of AODV in formation is distributed between the source node and the intermediate nodes. OLSR and DSDV protocols keep routing table updated to transmit the data quickly.

5

Conclusion and Future Work

5.1 Conclusion

Packet delivery rate for DSR is comparably higher than DSR, OLSR, DSDV and AODV indicating its better efficiency. DSR and AODV both will perform comparably better under highly mobile condition than DSDV. Frequent link failures happens due to the high overhead involved in repeated updating of all the nodes with the new routing information as in DSDV is much more than that involved in AODV and DSR. But in case of DSR, it uses route caches and source routing; so it is independent on any periodic or timer-based activities. DSR uses caching mechanism for route storing and maintains of multiple routes per destination. AODV, on the other hand, uses routing tables, one route per destination, and destination sequence numbers, a mechanism prone to loops and to determine freshness of routes. The general observation from the simulations is that, for application oriented scenario such as PEG (pursuit and evasion game) where mobile nodes are associated with constraints like bandwidth ,storage capacity ,battery power ,CPU capacity and storage capacity DSR can perform better compared to OLSR,DSDVand AODV .

5.2 Future Work

For future work, other multicasting routing protocol could be considered for simulation. Other performance metrics such as energy based mobility and link stability metrics can be considered during simulations. Recently developed protocol BATMAN (Better approach to mobile adhoc network) showing promising results as designed in a way to have robustness of OLSR protocol and much more energy efficient than DSR, could be considered for simulation and hardwire implementation.

REFERENCES

[1] Murthy, S. and J.J. Garcia-Luna-Aceves, "An Efficient Routing Protocol for Wireless Networks", *ACM Mobile Networks and App. J., Special Issue on Routing in Mobile Communication Networks*, Oct.1996, pp. 183-97.

.

[2] D. Johnson, D. A. Maltz, "Dynamic source routing in ad hoc wireless networks", *in Mobile Computing (T. Imielinski and H. Korth, eds.)*, Kluwer Acad. Publ., 1996.

[3] C.E. Perkins and E.M. Royer, "Ad hoc on demand Distance Vector routing", *mobile computing systems and applications, 1999.Proceedings. WMCSA '99. Second IEEE Workshop on*, 1999, p90 -p100.

[4] Z. J. Haas and M.R Pearlman, "The Zone Routing Protocol (ZRP) for ad hoc networks", *IETF Internet draft* , August 1998.

[5] P. Jacquet, P. Muhlethaler, and A. Qayyum, "Optimized Link State Routing Protocol", *IETF MANET, Internet draft*, 1998.

[6] H. Ehsan and Z. A. Uzmi (2004),"Performance Comparison of Ad HocWireless Network Routing Protocols", *IEEE INMIC* 2004.

[7] C.W. Wu, Y.C. Tay, "AMRIS: a multicast protocol for ad hoc wireless networks", *Proceedings IEEE MILCOM'99, Atlantic City*,Nov. 1999.

[8] S.J. Lee, M. Gerla, C.C. Chiang, "On Demand Multicast Routing Protocol", *Proceedings of IEEE WCNC'99, New Orleans*, pages 1298-1302, Sept 1999.

[9] A.B.Mnaouer, L. Chen, C. H. Foh, and J.W.Tantra, "OPHMR: An Optimized Polymorphic Hybrid Multicast Routing for MANETs", *IEEE transaction on mobile computing.* Vol 5, No. 6, May 2007.

[10] E. M. Royer and C. E. Perkins, "Multicast Operation of the Ad hoc On-Demand Distance Vector Routing Protocol", *Proceedings of IEEE MOBICOM'99, Seattle, WA,* August 1999, pp. 207-218.

[11] Richard G. Ogier, Fred L. Templin, Bhargav Bellur, and Mark G. Lewis, "Topology Broadcast Based on Reverse-Path Forwarding (TBRPF)", *draft-ietf-manet-tbrpf-05.txt,* March 2002.

[12] Mario Gerla, Xiaoyan Hong, and Guangyu Pei, "Fisheye State Routing Protocol (FSR) for Ad Hoc Networks", *draft-ietf-manet-fsr03.txt,* June 2002.

[13] David B. Johnson, "Routing in Ad Hoc Networks of Mobile Hosts",*Proceedings of the IEEE workshop on Mobile Computing Systems and Applications,* December 1994.

[14] Asma Tuteja, Rajneesh Gujral, and Sunil Thalia, "Comparative Performance Analysis of DSDV, AODV and DSR Routing Protocols in MANET Using NS3," International Conference on Advances in Computer Engineering, pp. 330-333, 2010.

[15] Samuel Senkindu, and H. Anthony Chan, "Enabling end-to-end quality of service in a WLAN-wired network," IEEE Conference on Military Communications, pp. 1-7, 2008.June 2001.

[16] V. Park, and S. Corson, "Temporally-Ordered Routing Algorithm (TORA)", *Version 1 Functional Specification. IETF Internet draft,* 1997.

[17] Tao Yang, Elis Kulla, Leonard Barolli, Gjergji Mino, and Makoto Takizawa, "Performance Comparison of Wireless Sensor Networks for Different Speeds of Multi Mobile Sensor Nodes," International Conference on Advanced Information Networking and Applications Workshops, vol. 27, pp. 371-376, 2013.

[18] K. Khan, Rafi U. Zaman, and A. Venugopal Reddy, "A Bi-directional connectivity framework for mobile ad hoc network and the Internet," IFIP on Wireless Days, vol. 1, pp. 1-5, 2008.

[19] Dipobagio, Martinus, "An Overview on Ad Hoc Networks,"

[20] K. Khan, Rafi U. Zaman, and A. Venugopal Reddy, "A Bi-directional connectivity framework for mobile ad hoc network and the Internet," IFIP on Wireless Days, vol. 1, pp. 1-5, 2008.

[21] Arindam Ghosh, Aboubaker Lasebae, and Enver Ever, "Performance Evaluation of Wireless IEEE 802.11 (b) used for Ad-Hoc Networks in an E-Learning Classroom Network,"

[22] T. V. Lakshman, and Upamanyu Madhow, "The performance of TCP/IP for networks with high bandwidth-delay products and random loss," IEEE/ACM Transactions on Networking, vol. 5-3, pp.336-350, 1997.

[23] Samuel Senkindu, and H. Anthony Chan, "Enabling end-to-end quality of service in a WLAN-wired network," IEEE Conference on Military Communications, pp. 1-7, 2008.

[24] R. Misra, C. R. Manda (2005)l,"Performance Comparison of AODV/DSR On-Demand Routing Protocols for Ad Hoc Networks in Constrained Situation", *IEEE ICPWC* 2005.

[25] Kant, Kamal, and Lalit K. Awasthi. "Unicast and multicast routing protocols for manets: A comparative survey." *Int. J. IT Knowl. Manag.(IJITKM), ISSN*(2010): 0973-4414.